

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listing of claims in the application.

Listing of Claims:

1. (currently amended) A piezoelectric current sensor comprising:

a piezoelectric element having a first face and a second face;

a first electrical conductor for carrying a current to be sensed, the first electrical conductor being attached to the first face of the piezoelectric element; and

a second electrical conductor for carrying a reference current, the second electrical conductor being attached to the second face of the piezoelectric element and aligned substantially parallel to the first electrical conductor;

wherein a force between the first and second electrical conductors caused by the current to be sensed and the reference current is applied to the piezoelectric element and produces an electrical potential between the first and second faces of the piezoelectric element, and wherein the sensitivity of the piezoelectric current sensor is adjusted by adjusting the level of the reference current.

2. (original) A piezoelectric current sensor in accordance with claim 1, further comprising:

a first conductive layer attached to the first face of the piezoelectric element; and

a second conductive layer attached to the second face of the piezoelectric element.

3. (original) A piezoelectric current sensor in accordance with claim 2, further comprising:

a charge amplifier electrically coupled to the first and second conductive layers and operable to produce an output signal representative of the electrical potential between the first and second faces of the piezoelectric element.

4. (original) A piezoelectric current sensor in accordance with claim 2, wherein the first electrical conductor is electrically isolated from the first conductive layer and the second electrical conductor is electrically isolated from the second conductive layer.

5. (original) A piezoelectric current sensor in accordance with claim 1, further comprising a current source coupled the second electrical conductor and operable to produce the reference current in the second electrical conductor.

6. (currently amended) A piezoelectric current sensor in accordance with claim 5, wherein the current source is operable to adjust ~~vary~~ the level of the reference current in response to a control signal.

7. (currently amended) A piezoelectric current sensor ~~in accordance with claim 1,~~ comprising:

a piezoelectric element having a first face and a second face;

a first electrical conductor for carrying a current to be sensed, the first electrical conductor being attached to the first face of the piezoelectric element; and

a second electrical conductor for carrying a reference current, the second electrical conductor being attached to the second face of the piezoelectric element and aligned substantially parallel to the first electrical conductor;

wherein a force between the first and second electrical conductors caused by the current to be sensed and the reference current is applied to the piezoelectric element and produces an electrical potential between the first and second faces of the piezoelectric element, and wherein the level of the reference current is modulated to enable measurement of a direct current in the first conductor.

8. (currently amended) A piezoelectric current sensor ~~in accordance with claim 1, further~~ comprising:

a piezoelectric element having a first face and a second face;

a first electrical conductor for carrying a current to be sensed, the first electrical conductor being attached to the first face of the piezoelectric element;

a second electrical conductor for carrying a reference current, the second electrical conductor being attached to the second face of the piezoelectric element and aligned substantially parallel to the first electrical conductor;

a substrate; and

a compliant layer positioned between the piezoelectric element and the substrate and attaching the piezoelectric element to the substrate,

wherein a force between the first and second electrical conductors caused by the current to be sensed and the reference current is applied to the piezoelectric element and produces an electrical potential between the first and second faces of the piezoelectric element, and wherein the compliant layer is more compliant than the piezoelectric element.

9. (original) A piezoelectric current sensor in accordance with claim 1, further comprising a magnetic shield surrounding the piezoelectric current sensor.

10. (original) A piezoelectric current sensor in accordance with claim 1, wherein the magnetic shield surrounding the piezoelectric current sensor is made of Mu metal.

11. (currently amended) A piezoelectric current sensor ~~in accordance with claim 1,~~ comprising:

a piezoelectric element having a first face and a second face;

a first electrical conductor for carrying a current to be sensed, the first electrical conductor being attached to the first face of the piezoelectric element;

a second electrical conductor for carrying a reference current, the second electrical conductor being attached to the second face of the piezoelectric element and aligned substantially parallel to the first electrical conductor; and

a fixed resistance in series with the second conductor to form a reference circuit

wherein a force between the first and second electrical conductors caused by the current to be sensed and the reference current is applied to the piezoelectric element and produces an electrical potential between the first and second faces of the piezoelectric element, and wherein the reference current is generated by applying a reference voltage to the reference circuit.

12. (currently amended) An integrated circuit comprising:

a plurality of electronic components;

a substrate supporting the plurality of electronic components;

a plurality of electrical conductors linking one or more of plurality of electronic components;

a piezoelectric element having a first face and a second face, the first face being attached to a first electrical conductor of the plurality of electrical conductors; ~~and~~

a second electrical conductor for carrying a reference current, the second electrical conductor being attached to the second face of the piezoelectric element and aligned parallel to the first electrical conductor; and

a compliant layer positioned between the piezoelectric element and the substrate and attaching the piezoelectric element to the substrate

wherein a force between the first and second electrical conductors is applied to the piezoelectric element and produces an electrical potential between the first and second faces of the piezoelectric element indicative of the current flowing in the first electrical conductor.

13. (original) An integrated circuit in accordance with claim 12, further comprising:

a first conductive layer attached to the first face of the piezoelectric element; and

a second conductive layer attached to the second face of the piezoelectric element.

14. (original) An integrated circuit in accordance with claim 12, further comprising a charge amplifier electrically coupled to the first and second conductive layers and operable to produce an output signal representative of the electrical potential between the first and second faces of the piezoelectric element.

15. (original) An integrated circuit in accordance with claim 13, wherein the first electrical conductor is electrically isolated from the first conductive layer

and the second electrical conductor is electrically isolated from the second conductive layer.

16. (original) An integrated circuit in accordance with claim 12, further comprising a current source coupled the second electrical conductor and operable to produce the reference current in the second electrical conductor.

17. (cancelled)

18. (original) A piezoelectric current sensor comprising:

a plurality of piezoelectric elements each having a first face and a second face;

a plurality of first electrical conductors, each of the plurality first electrical conductors being attached to a first face of a piezoelectric element of the plurality of piezoelectric elements and each being capable of carrying a current to be sensed; and

a second electrical conductor for carrying a reference current, the second electrical conductor being attached to the second face of each of the plurality of piezoelectric elements and aligned parallel to a first electrical conductor of the plurality of first electrical conductors,

wherein a force between a first electrical conductor and the second electrical conductor is applied to a corresponding piezoelectric element and produces an electrical potential between the first and second faces of the piezoelectric element.

19. (currently amended) A method for sensing an electrical current in a first conductor of a piezoelectric current sensor, the piezoelectric current sensor further comprising a piezoelectric element having a first face attached to the first conductor and second face attached to a second conductor aligned substantially parallel to the first conductor, the method comprising:

passing a reference current through the second conductor to produce a force between the first and second conductors that is applied to the piezoelectric element; ~~and~~

measuring the voltage potential between the first and second faces of the piezoelectric element; and

adjusting the sensitivity of the piezoelectric current sensor by adjusting the reference current level.

20. (original) A method in accordance with claim 19, wherein measuring the voltage potential between the first and second faces of the piezoelectric element comprises electrically coupling the first and second faces of the

piezoelectric element to a charge amplifier and sensing the output from the charge amplifier.

21. (cancelled)

22. (currently amended) A method ~~in accordance with claim 19, further comprising~~ for sensing an electrical current in a first conductor of a piezoelectric current sensor, the piezoelectric current sensor further comprising a piezoelectric element having a first face attached to the first conductor and second face attached to a second conductor aligned substantially parallel to the first conductor, the method comprising:

passing a reference current through the second conductor to produce a force between the first and second conductors that is applied to the piezoelectric element;

measuring the voltage potential between the first and second faces of the piezoelectric element; and

modulating the reference current level.

23. (original) A method in accordance with claim 22, wherein the reference current level is modulated by one of a sinusoidal wave, a triangular wave, and a square wave.

24. (currently amended) A method ~~in accordance with claim 19, further~~
~~comprising~~ for sensing an electrical current in a first conductor of a
piezoelectric current sensor, the piezoelectric current sensor further
comprising a piezoelectric element having a first face attached to the first
conductor and second face attached to a second conductor aligned
substantially parallel to the first conductor, the method comprising:

passing a reference current through the second conductor to produce a
force between the first and second conductors that is applied to the
piezoelectric element;

measuring the voltage potential between the first and second faces of
the piezoelectric element; and

determining the current in the first conductor by multiplying the voltage
potential by a calibration factor.

25. (currently amended) A method ~~in accordance with claim 19, further~~
~~comprising~~ for sensing an electrical current in a first conductor of a
piezoelectric current sensor, the piezoelectric current sensor further
comprising a piezoelectric element having a first face attached to the first
conductor and second face attached to a second conductor aligned
substantially parallel to the first conductor, the method comprising:

passing a reference current through the second conductor to produce a force between the first and second conductors that is applied to the piezoelectric element;

measuring the voltage potential between the first and second faces of the piezoelectric element; and

determining the current in the first conductor by multiplying the voltage potential by a calibration factor and dividing by the reference current.

26. (currently amended) A method ~~in accordance with claim 19, further comprising~~ for sensing an electrical current in a first conductor of a piezoelectric current sensor, the piezoelectric current sensor further comprising a piezoelectric element having a first face attached to the first conductor and second face attached to a second conductor aligned substantially parallel to the first conductor, the method comprising:

passing a reference current through the second conductor to produce a force between the first and second conductors that is applied to the piezoelectric element;

measuring the voltage potential between the first and second faces of the piezoelectric element; and

determining the current in the first conductor by multiplying the voltage potential by a calibration factor and dividing by a reference voltage.

27. (currently amended) A method ~~in accordance with claim 19, further comprising~~ for sensing an electrical current in a first conductor of a piezoelectric current sensor, the piezoelectric current sensor further comprising a piezoelectric element having a first face attached to the first conductor and second face attached to a second conductor aligned substantially parallel to the first conductor, the method comprising:

passing a reference current through the second conductor to produce a force between the first and second conductors that is applied to the piezoelectric element;

measuring the voltage potential between the first and second faces of the piezoelectric element; and

determining a voltage applied across the first conductor dependent upon the electrical resistance of the first conductor and the current in the first sensor.

28. (cancelled)

29. (currently amended) A piezoelectric current sensor ~~in accordance with claim 28, further comprising:~~

a piezoelectric element having a first face and a second face;

a first electrical conductor for carrying a current to be sensed, the first electrical conductor being attached to the first face of the piezoelectric element;

a means for generating a reference current;

a second electrical conductor for carrying the reference current, the second electrical conductor being attached to the second face of the piezoelectric element and aligned substantially parallel to the first electrical conductor;

a means for measuring the electrical potential between the first and second faces of the piezoelectric element produced by a force between the first and second electrical conductors that is applied to the piezoelectric element; and

a means for modulating the reference current to facilitate measurement of direct currents in the first conductor.

30. (currently amended) A piezoelectric current sensor ~~in accordance with claim 28, further comprising:~~

a piezoelectric element having a first face and a second face;

a first electrical conductor for carrying a current to be sensed, the first electrical conductor being attached to the first face of the piezoelectric element;

a means for generating a reference current;

a second electrical conductor for carrying the reference current, the second electrical conductor being attached to the second face of the piezoelectric element and aligned substantially parallel to the first electrical conductor;

a means for measuring the electrical potential between the first and second faces of the piezoelectric element produced by a force between the first and second electrical conductors that is applied to the piezoelectric element; and

a means for varying the level of the reference current.

31. (original) A piezoelectric current sensor in accordance with claim 30, wherein the means for varying the level of the reference current is operable to vary the level in response to the level of the current to be sensed.

32. (currently amended) A piezoelectric current sensor in accordance with claim 29 28, wherein the means for measuring the electrical potential between the first and second faces of the piezoelectric element includes first and second conductive layers electrically coupled to the first and second faces of the piezoelectric element respectively and an means for amplifying the charge difference between the first and second conductive layers.

33. (currently amended) A piezoelectric current sensor in accordance with claim 29 28, further comprising means for electrically coupling the current to be sensed to the first conductor.

34. (currently amended) A piezoelectric current sensor in accordance with claim 29 28, wherein the piezoelectric element comprises one of quartz crystal, lead zirconate titanate (PZT) ceramic and polyvinylidene fluoride (PVDF) polymer.

35. (currently amended) A method for calibrating a piezoelectric current sensor, comprising:

passing a known direct current I_0 through a first electrical conductor attached to a first face of a piezoelectric element;

passing a modulated reference current I_{REF} through a second electrical conductor attached to a second face of the piezoelectric element; and

measuring the level V_0 of the output signal from a charge amplifier operable to amplify the electrical potential across the piezoelectric element.

36. (original) A method in accordance with claim 35, further comprising dividing the product of the known current and the reference current by the level of the output signal to obtain a calibration constant. $\alpha = \frac{I_0 \cdot I_{REF}}{V_0}$, such that in operation the current I in the first conductor is given by $I = \alpha \frac{V_0}{I_{REF}}$.